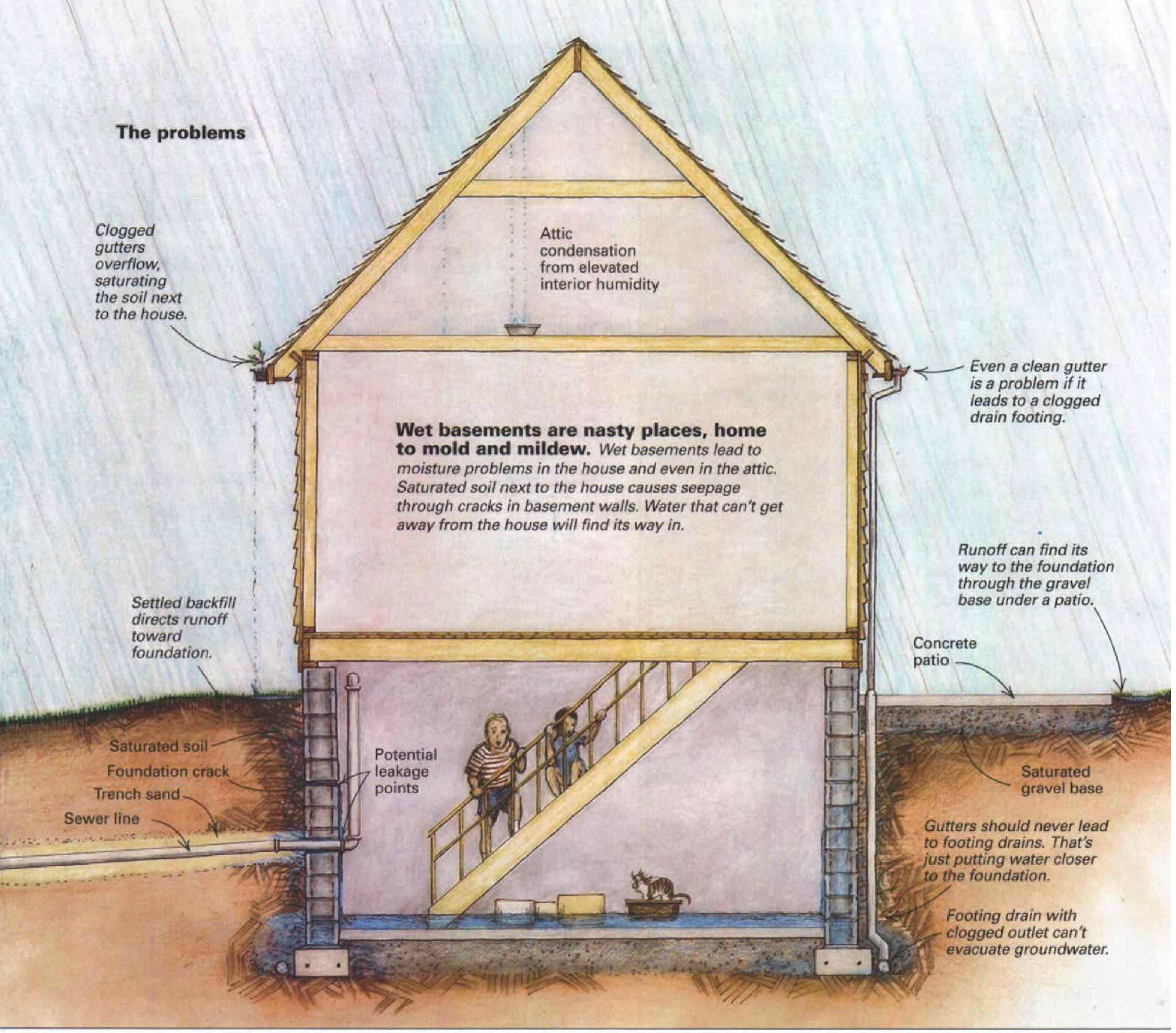
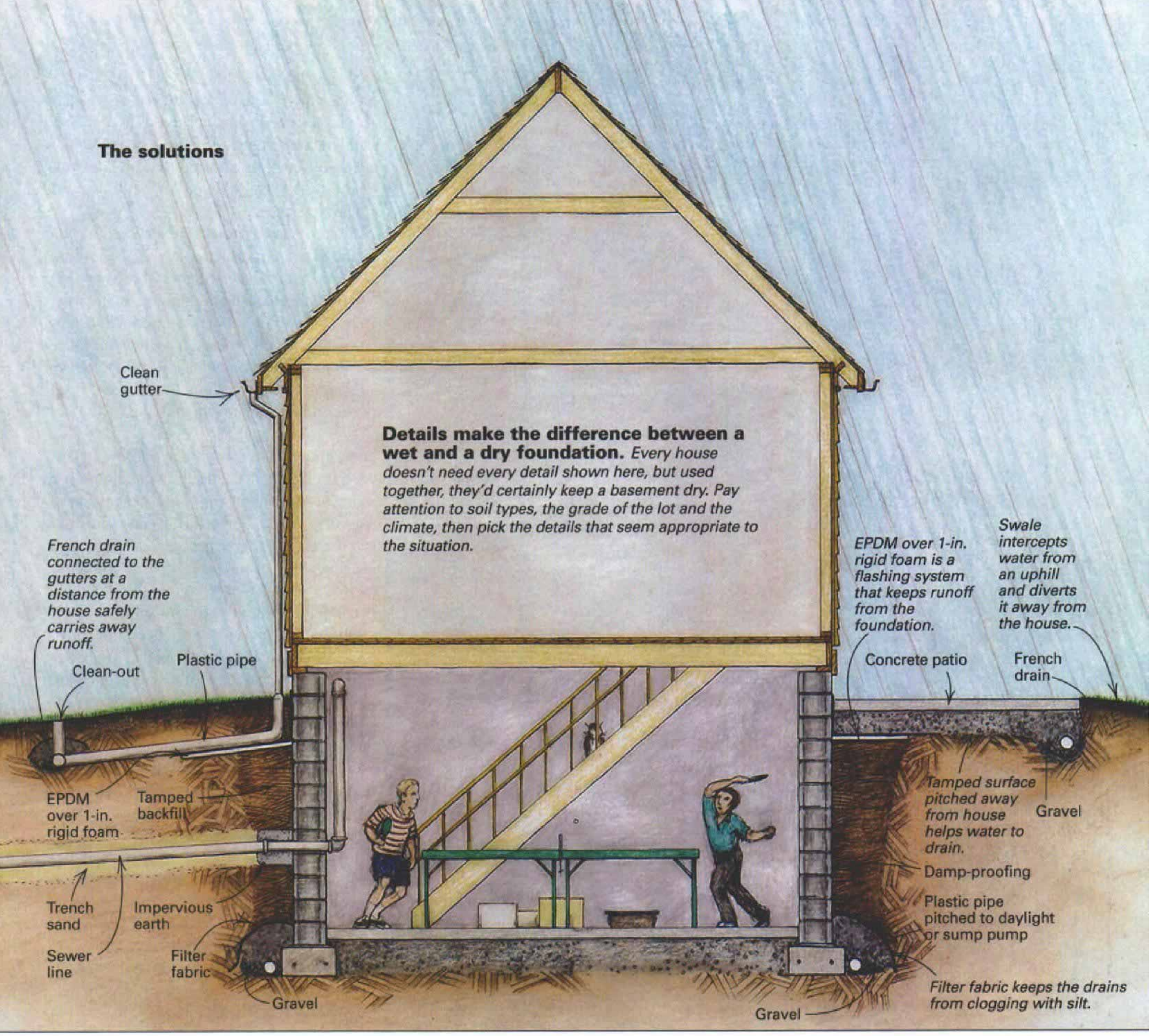


Details for a Dry Foundation

Think of the ground around the house as the roof that keeps the foundation dry

by William B. Rose

Drawings: Christopher Clapp



As a research architect at the Building Research Council of the University of Illinois, I am paid to solve some of the more nagging problems that houses have. Frequently, I visit troubled houses, and the most common problem I encounter is poor drainage away from the foundation. This problem became worse as wetlands were developed; I know what to expect when the name of the development is Frog Hollow.

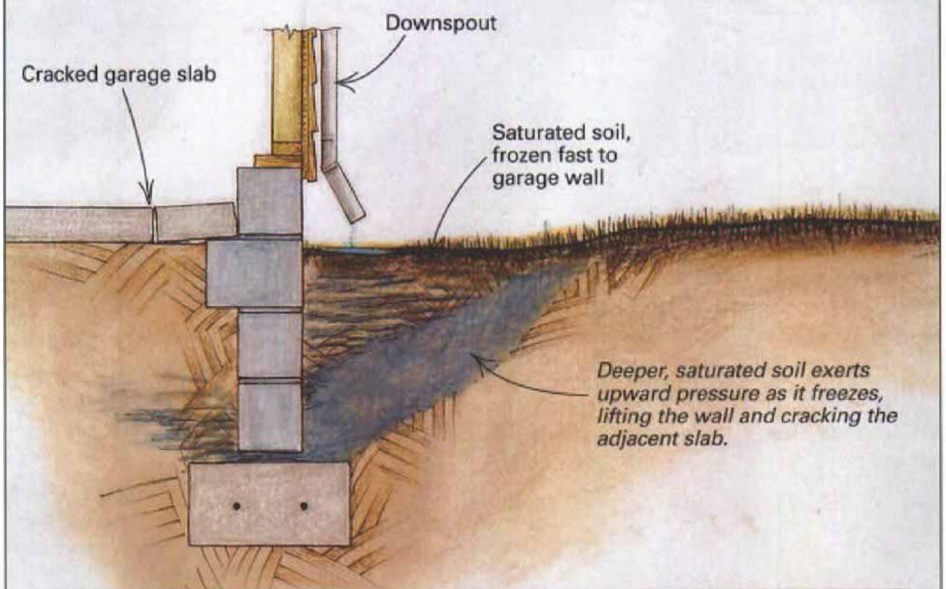
I was once asked to look at a house that had settling problems. There was an addition, built over a crawlspace, that was moving down relative to the main house. The dirt floor of the crawlspace was low, even with the bottom of the footing. The soil along the edge of the footing was in small, rounded clumps, unlike the grainy, gritty surface of the rest of the floor. I dug away at the dirt clumps, and my fingers hit air. I dug a little more and found a space that reminded me of a prison escape tunnel. In all, 10 ft. of the footing was undermined.

Water from a downspout draining too near the corner of the house and the addition was the culprit. The water was taking the path of least resistance to the footing drain and sump pump in the basement of the main part of the house. That path happened to be under the addition's footing. By following that path, the runoff had washed away the ground under the footing and caused the addition to settle.

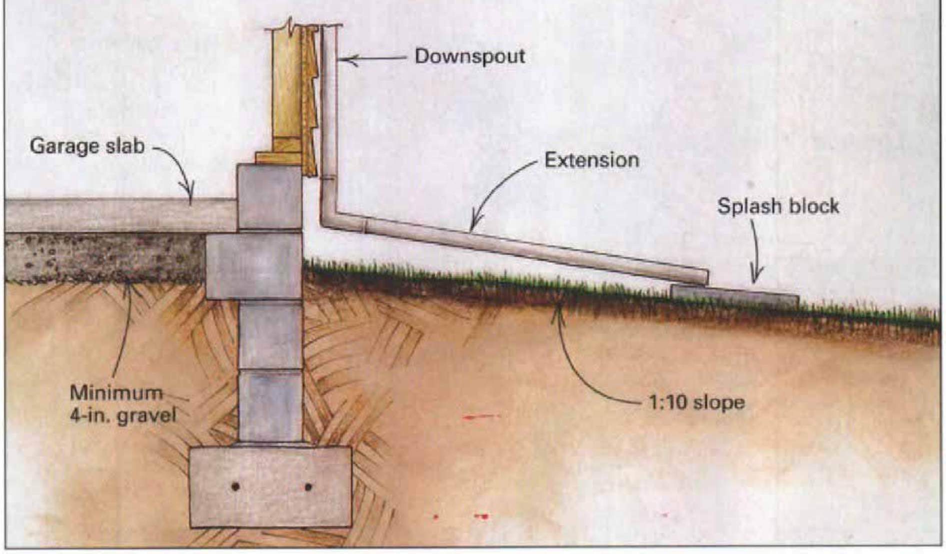
Bad drainage can cause a raft of problems—I call my studies of the zone where the house meets the ground "building periodontics." Proper preventative care of this area can avoid a variety of problems, some less obvious and a lot more serious than a damp cellar.

For example, a common problem in basements, particularly those with block walls, is in-

Saturated soil leads to frost heaving. *In a common scenario, water from downspouts has nowhere to go but next to the foundation. This results in damage to a garage slab from soil freezing.*



Keeping water away is the solution. *Proper detailing can be as simple as sloping the ground away from the house and using downspout extensions to deposit runoff away from the backfill onto undisturbed soil.*



ward buckling. This usually shows up as a horizontal crack one or two blocks below grade, or at windowsills, stepping up or down at the corners. A study I did with the Illinois State Geological Survey revealed the cause. Clay soils shrink during dry spells, forming a crevice between the soil and the foundation wall. Wind and light rains carry dirt into this crevice. Then, when seasonal rains come, the soil swells back to its original dimension, plus the increment of added soil. Over time, the wall is ratcheted inward and eventually buckles. You avoid this problem by keeping the soil next to the foundation dry.

Slabs suffer from water problems, too. Garage floors, for example, commonly crack at outside corners near where gutters drain. This cracking may be due to upward expansion of water directly below the corner. It can also be due to adhesion lifting of the perimeter wall, a situation occurring when saturated soil freezes fast to the foundation wall (drawing left). The soil nearest the surface is the first to freeze, and as the cold weather continues, deeper soil freezes. This saturated soil expands by 8% as it freezes, and it exerts a tremendous force that lifts the soil frozen to the wall above. The wall lifts and cracks the slab.

Moisture damage around foundations isn't limited to masonry problems. In 1947, Ralph Britton, the government researcher whose work led to the current attic-ventilation standards, showed that water vapor traveling upward from damp foundations caused most attic moisture problems. He concluded that if attics were isolated from wet foundations, the standard 1:300 venting ratio could be reduced to 1:3,000.

First, pinpoint the trouble spots—Let's take a walk around an imaginary house and study the sources of its foundation water problems (drawing p. 98). We easily spot the first one: The front gutters are clogged. Been clogged for so long, in fact, that saplings are sprouting in the composted leaves. Rainwater overflows these gutters, causing the ground below to settle. A small crater has developed, and its contents have nowhere to drain but down and into the cellar.

The gutters at the back of the house, however, are clean. The leader feeds into an underground drain that goes... where? Walking downhill, we find an outlet pipe at about the right elevation to be a footing drain. Composting leaves and granules from asphalt shingles clog the corrugated pipe. Might the water that should flow from this pipe be ending up in the basement?

A concrete patio, probably poured on a sand or gravel base, extends off the back of the house. A shallow depression next to the patio's edge collects a pool of runoff. This collected water will drain down the path of least resistance-through the gravel, under the patio and down the foundation wall.

Going into the basement, we find leaks in places that confirm our observations. There is also a leak where the sewer line exits the house, indicating that water is flowing into the house through the sand in which the sewer line is laid.

Timing can provide clues to the source of leaks. If they occur in a matter of hours following a rain, the problem is surface water. If leaks follow a day or so after a rain, a rising water table is likely the cause.

Know your soil—As I write this article, I am sitting in the middle of the Midwest. The soil here is Drummer silty-clay loam, great for agriculture, murder on construction. The available water capacity is about 20%. This means that if I had 5 cu. in. of dry soil, adding I cu. in. of water would saturate it. Being clay, the soil will swell as I add water. The permeability is about I in./hr.

This means that any layer of rain will need an hour to get through a horizontal layer of soil 1 in. thick. That's really slow. From these numbers, I can estimate that a 1-in. rain will saturate 5 in. of soil and take five hours for full penetration.

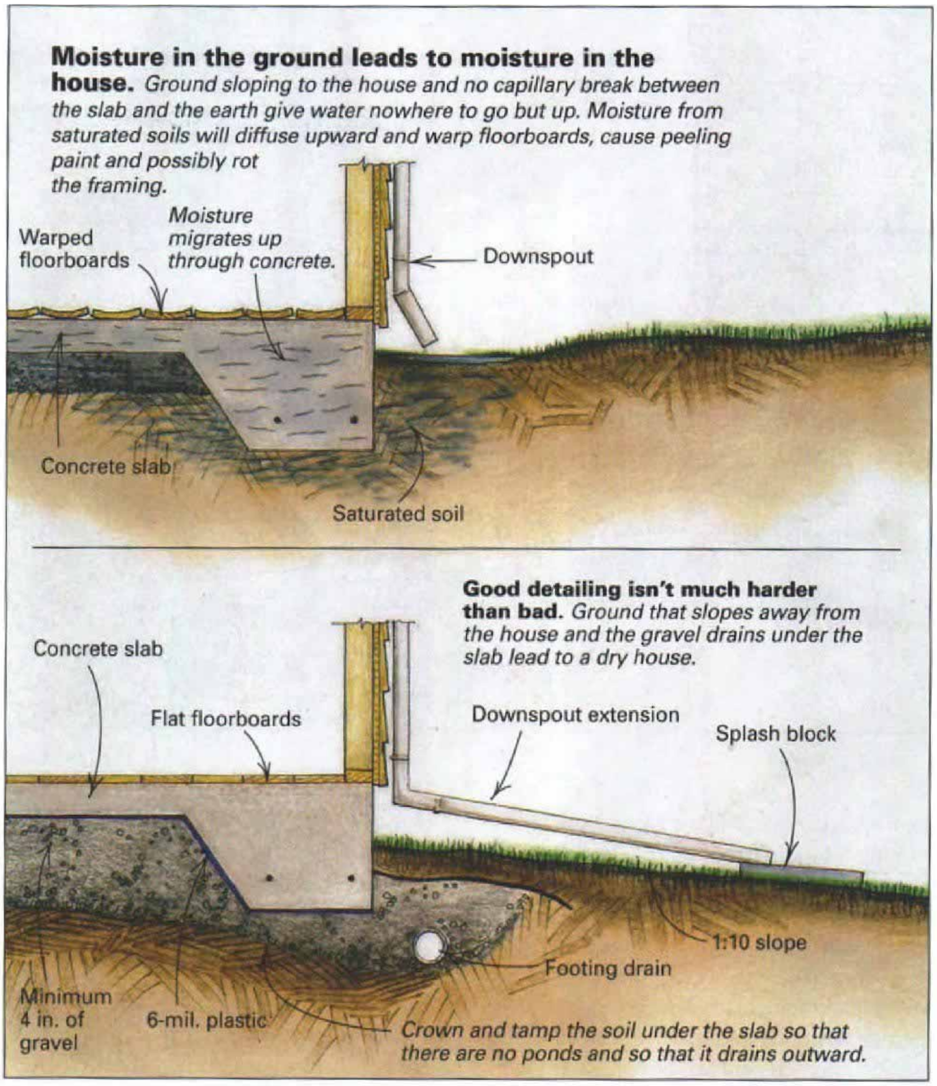
That's useful information. It is from the U. S. Department of Agriculture's county-soil survey, available from your county cooperative extension service agent. It allows a builder to estimate how much vertical water penetration there will be and how much of the rain runoff must be treated as sheet flow on the surface. This information matters a lot more on flat lots than on sloped ones, but it can still be important on the uphill side of sloping sites.

The perc test for septic systems is also a good predictor of how well the soil drains. If your soils have a good percolation rate, say, 10 in./hr. to 15 in./hr., to below the bottom of your footings, you may not have to do much to ensure a dry foundation. Install gutters and downspouts and make sure the first 10 ft. of ground around your house slopes away at something like 1 ft. in 10.

First lines of defense—What if your percolation rate is considerably less than 10 in./hr.? First, don't build on the lowest part of the lot, because that is where the water will go.

Gutters and downspouts are at the heart of rainwater management, the heart of moisture control in buildings. Deposit rainwater from gutters onto splash blocks and onto undisturbed soil so that the water runs away from the house.

Most modern houses are damp-proofed *(FHB* #95, pp. 48-53)—that is, the exterior of the basement wall receives a bitumen coating. This provides a considerable amount of water protection. But water can enter through cracks resulting from utility penetrations, concrete curing, settlement, swelling soils, seismic activity or other causes. Think of damp-proofing as a secondary defense against water.



Moisture in the ground leads to moisture in the house. *Ground sloping to the house and no capillary break between the slab and the earth give water nowhere to go but up. Moisture from saturated soils will diffuse upward and warp floorboards, cause peeling paint and possibly rot the framing.*

Good detailing isn't much harder than bad. *Ground that slopes away from the house and the gravel drains under the slab lead to a dry house.*

Dealing with a rising water table—Footing drains have been used for decades to intercept rising groundwater. Rising groundwater usually isn't the major problem for foundations. Surface water is much more likely to cause trouble if it isn't led away from the foundation. Still, footing drains should be installed. They don't cost much when you're excavating, anyway, and they're the devil to retrofit if you find later that you have a high water table.

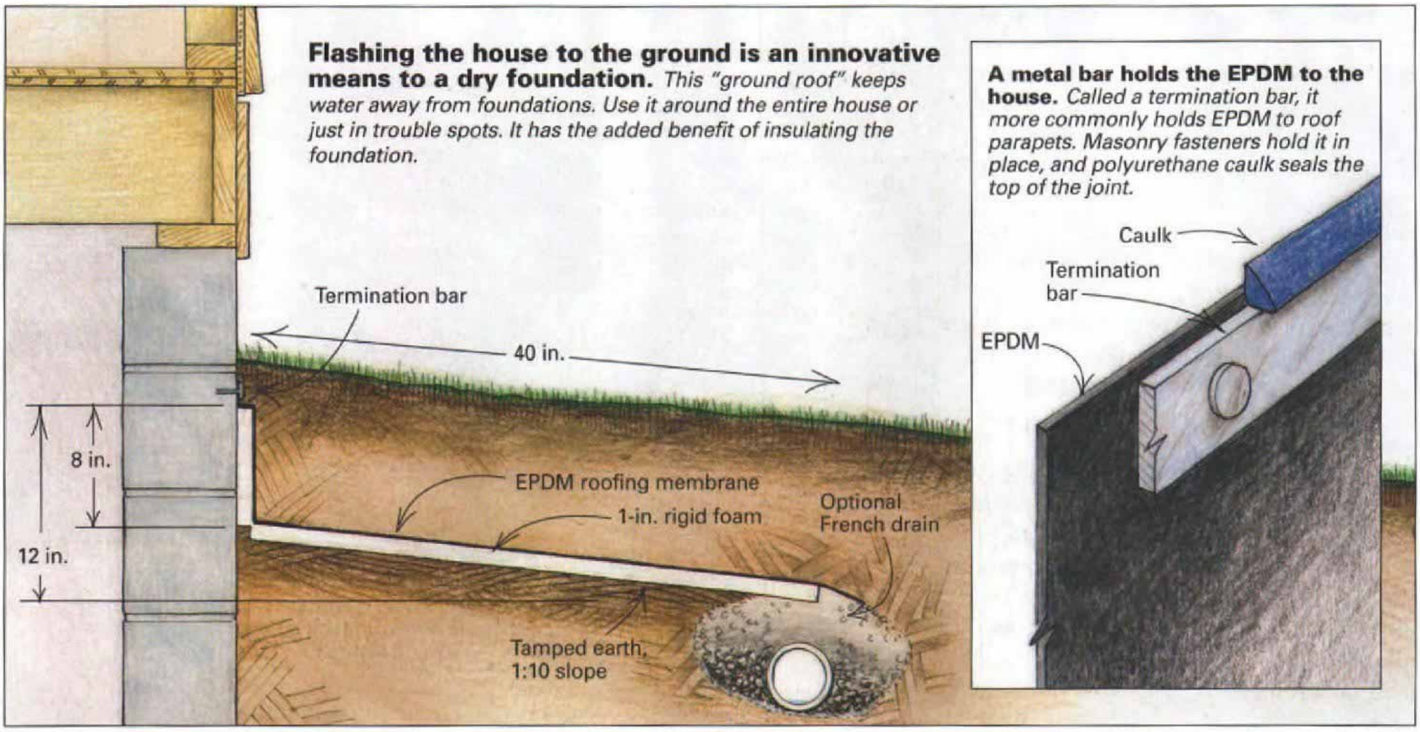
Footing drains should consist of a foot or so of gravel around the outside of the foundation. Use a filter fabric over the gravel to keep it from clogging with silt. Filter fabric comes in several weights; the lightest is just fine for residential use. Footing drains can have 4-in. perforated plastic pipe with the holes pointing down. They must lead to a sump pump or a gravity drain consisting of solid pipe leading to daylight. If you use pipe (as opposed to just gravel) in a footing drain, it should be slightly pitched toward the outlet, or at least not pitched backward. It should have surface clean-outs every 50 ft. Discharge by gravity flow is preferable to a sump pump. Sump pumps are a weak link, likely to fail when most needed, but a gravity drain may not be possible if the footing drains are deeper than any possible discharge point.

Gravel alone is probably just as good as gravel with pipes in it. A continuous gravel base that leads to a sump pump or to a daylight drain of solid 4-in. plastic pipe will handle most rising groundwater. The gravel is the main water route, so pipe used as a collector is not critical. In fact, I believe that most pipe is placed by people who don't really know what water is supposed to go where. Drain pipe here symbolizes good practice while making a doubtful contribution.

Never connect the downspouts to the footing drains, even if the drains run to daylight and not to a sump pump. Putting that volume of water closer to the footings makes no sense at all in light of my opening story. I'm trying to solve problems here, not create them.

Good backfilling and grading are crucial—Proper backfill procedures go a long way toward eliminating water problems. At the risk of sounding simplistic, be sure the ground slopes away from the house. You'd be amazed how many builders get this wrong. I recommend a slope of 12 in. in the first 10 ft. as a minimum (drawing above). Builders commonly don't allow enough extra soil for settling, and they almost never compact the backfill. Lightly compacted backfill may settle 5% of its height or more, often resulting in a situation where the grade pitches toward the house. When backfilling, include a correction for settlement. There really aren't any hard-and-fast rules. Deep, lightly compacted backfill needs a big correction. Shallow, well-compacted fill might require none. Remember, too much slope near the house doesn't create water problems; too little does.

Compact the backfill as tightly as possible without damaging the foundation walls. Brace



Flashing the house to the ground is an innovative means to a dry foundation. *This "ground roof" keeps water away from foundations. Use it around the entire house or just in trouble spots. It has the added benefit of insulating the foundation.*

A metal bar holds the EPDM to the house. *Called a termination bar, it more commonly holds EPDM to roof parapets. Masonry fasteners hold it in place, and polyurethane caulk seals the top of the joint.*

them well, using trusslike assemblies of heavy framing lumber spanning from wall to wall. Have the first-floor deck on, and fill all sides evenly. Block walls require more caution than poured concrete. Compact the backfill in 1-ft. lifts using a hand compactor, commonly called a jitterbug, or careful pressure from a backhoe. Because intersecting walls brace each other, the soil at outside corners can be compacted with less risk than in the middle of a long wall. For a minimum, compact these corners well, and be sure that all the downspouts drain near them.

Take special care where utility lines enter the house. They are frequently laid in sand that provides a direct path for water to reach the foundation. Be sure the soil under the utilities is well compacted, and cement and damp-proof the utility penetrations. Then use an impervious earth such as clay soil, or mix a bag of portland cement with the soil you have, to fill around the utility penetration. Tamp well (drawing p. 99).

Slab construction needs good detailing prior to the pour—Getting water away from slab foundations is just as critical as with basements or crawlspaces. Remember, there are retrofit draining and venting options that can, to a degree, rescue a damp basement or crawlspace. There are none that work on slabs.

Good preparation of the ground surface is critical prior to slab placement (drawing p. 5). Level the center, slope down to the excavation for the thickened edge of the slab, and compact the soil well. Pour the slab on 6-mil polyethylene over at least a 4-in. tamped gravel base. This base serves as a capillary break between the soil and the underside of the slab. Extend the gravel base to a footing drain to carry water away. It is important to remember that a capillary break works only as long as it remains unflooded.

Swales and French drains—Other means of transporting water away from the house besides sheet flow (when the surface is effectively running water) are the swale and the French drain. A swale is a small valley formed by two sloped soil surfaces. Swales must be pitched, or they become ponds. A swale should be located away from the building, and it is often used to divert sheet flow coming from uphill (drawing p. 99).

A French drain is a trench filled with rock or gravel that collects water and transports it laterally (top drawing, facing page). I prepare the bottom of the trench so that it is smooth and carefully pitched toward the outlet. Mix dry cement with the soil in the bottom of the trench to make it less permeable, and fill the trench with whatever clean gravel is locally available. I hesitate to use road stone, a blend of gravel and stone dust, because water passes through it slowly. If the gravel is to be exposed, I try to cap it with an attractive rounded stone. If the drain is to be covered, I provide graduated layers of smaller stone toward the surface, then perhaps filter fabric before the sod covering.

I sometimes use 4-in. smooth-wall perforated plastic pipe in a French drain, particularly if I expect it to carry a big volume of water, say runoff from the gutters. There are fittings that connect downspouts directly into this pipe. If you do this, install clean-outs at least every 50 ft. and keep the gutters clean. Otherwise, the pipe can become clogged with leaves. I don't use corrugated pipe for drainage because it is more difficult to ensure smooth, straight runs. It clogs more easily and is more difficult to clean out.

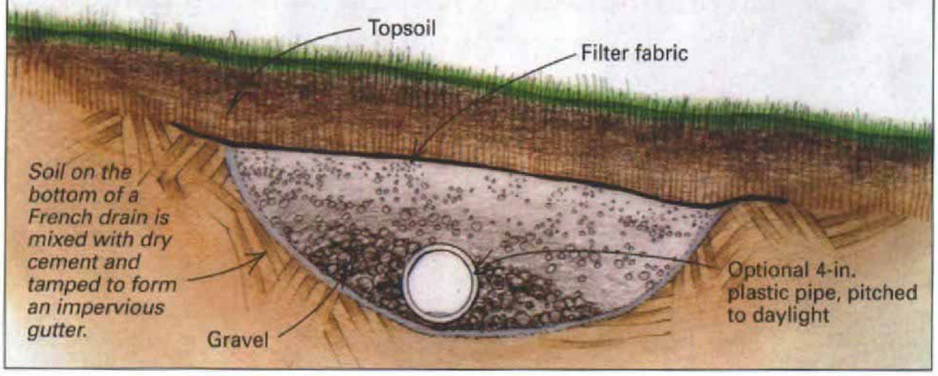
Concrete patios, stoops, driveways and sidewalks abutting the foundation present problems. It is important to design them so that the gravel base beneath drains outward, a perfect use for a French drain. You may find that the driveway is one of the most convenient sites for a French drain. Driveways usually pitch away from the house, and a French drain can be integrated with the driveway so that it will not call attention to itself.

Where should the water go?—To my knowledge, municipalities no longer provide storm-sewer service for new residential runoff. In my area, they do not receive the output from sump pumps. They receive and treat storm water to keep streets open, and that's about it.

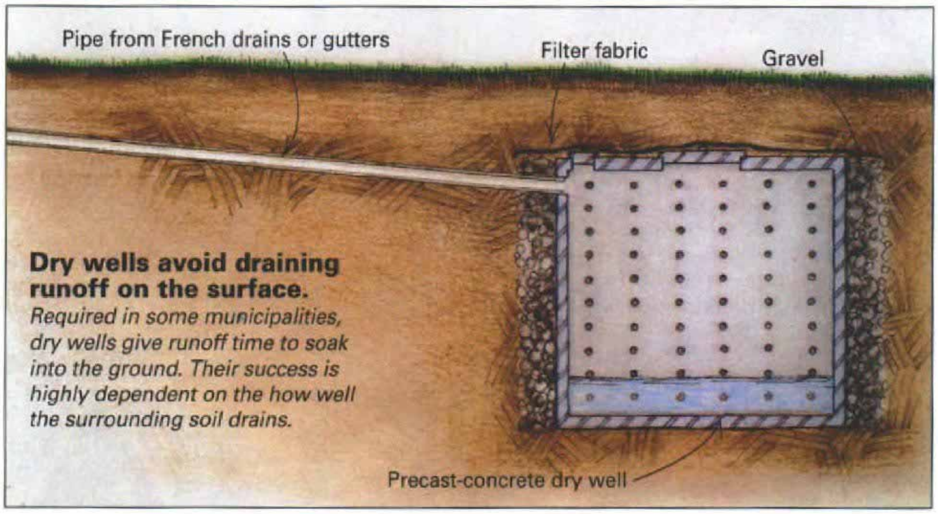
If there isn't enough elevation difference between the house and a point on the lot where a pitched drain can come to daylight, then another solution is needed. Theoretically, if the pipe never pitches back, you don't need more than the diameter of the pipe in elevation difference. Practically, more is better, and ¼ in. per ft. is a good number to shoot for.

But say you don't have even that much pitch. For hundreds of years, cisterns and dry wells collected water below grade. Often, there was an overflow toward a leach field. Such design is still feasible, and indeed it is useful for garden irrigation where fresh water is scarce. Some municipalities require new subdivisions to handle runoff with on-site dry wells, rather than feeding it to a common detention basin. Usually a 1,000-gal. precast-concrete dry well (drawing bottom right) or commercially available plastic drainage structures are buried somewhere on site. Water from the gutters is piped in and stored until it can soak into the surrounding soil. The likelihood of success with either one of these systems depends on the perc rate of the soil and sufficient storage capacity to handle the maximum likely runoff. It also depends on how big the design rainfall is.

If you are not required to treat runoff in a specific manner, then take advantage of natural drainage courses on your lot. Get the water away from the house responsibly. If several downspouts connect to a French drain, enough water may flow from it to cause erosion problems. Place rocks under the end of the pipe and in the outwash area to spread the flow out and reduce erosion. Don't flood the neighbors' basements to spare your own.



French drains collect and transport water. *A French drain can play an important role in draining slabs, gutters and ground-roof systems of water.*



Dry wells avoid draining runoff on the surface. *Required in some municipalities, dry wells give runoff time to soak into the ground. Their success is highly dependent on the how well the surrounding soil drains.*

Flashing the intersection of the ground and the foundation—I call that zone where the house meets the soil the "ground roof" because the soil surface must shed rainwater away from the foundation and the soil below. During dry spells, I commonly see a ½-in. crevice between the soil and the foundation. If that gap appeared on a roof, wouldn't we flash it? In severe cases or in old houses with hopelessly porous foundations, I have flashed this gap in the "ground roof" with EPDM roofing membrane (drawing facing page). Polyethylene sheets and bitumen membranes would work, but they degrade more easily when backfilled.

Ideally, I would flash a house as it was being built. In reality, I've done it only as a retrofit. The frost-protected shallow footing described in *FHB* #107 (pp.76-81) would lend itself well to a ground-flashing system. I dig down 8 in. at the foundation wall and extend outward 40 in., sloping the excavation 1 in. in 10. The hard work is the digging. Having done it, I should get as much benefit as possible, so I take this opportunity to insulate the foundation. Slice through one side of a 4x8 sheet of 1-in. rigid foam, 8 in. from the edge, and fold along the cut. The resulting piece fits neatly into the 8-in. by 40-in. excavation. In the South I suggest high-density mineral wool because it is less hospitable than foam to termites. In new construction, compact the backfill under the flashing well. Otherwise, settling could tear the EPDM from the wall or cause it to pitch toward the house.

After placing the insulation, I roll out the EPDM, letting it hang over the end of the foam. A metal strip called a termination bar, more commonly used to attach EPDM to roof parapets, clamps the membrane to the foundation at grade level. I attach the termination bar to the foundation with expanding nail-in fasteners, alloy or plastic sleeves that slide into holes drilled into the foundation and then expand as a nail is driven in. I run a bead of cutoff mastic, a high-quality polyurethane caulk used for waterproofing termination bars on roofs, on this joint and backfill.

The flashing could extend farther outward from the building at the downspout locations. In existing buildings, you can often get away with flashing only the trouble spots, usually inside comers with downspouts. The "ground roof" need not be as watertight as a house roof. After all, moisture control in soils is always a matter of playing the percentages.

In soils with an average percolation rate, flashing by itself is enough to keep the water away from the foundation. If your perc rate is slow, install a French drain near the outboard edge of the flashing. Shallow plantings can go right on top of the EPDM.

Consider your building site to be unique, and then plan accordingly—There are so many soil classifications, foundation types and climate variables that assembling general rules is challenging. If there is a general rule, it is this one: Design the soil surface that goes around the building to act as a roof. The overall aim is preventing the soil that is in contact with the building from being saturated with water. This "ground roof" should ensure that rainwater moves quickly and effectively away from the building. Downspout discharge, grading, flashing, drains and soil treatment at the surface all play major roles in keeping the ground in contact with the building dry.

Basements, crawlspaces and slabs all have their own peculiarities. With thoughtful design of the area where the house and the ground intersect, any foundation can be dry. Well, maybe any foundation that doesn't have provisions for boat docking. □

William B. Rose is research architect at the Building Research Council at the University of Illinois Urbana/Champaign.